APPLYING QUALIMETRIC FORECASTING IN AGRO-INDUSTRIAL COMPLEX

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Abstract: One of the effective ways to improve agricultural production competitiveness is Qualimetric Function Deployment (OFD) method. For all this, there is no clear qua lime trie forecasting methodology in agribusiness sector. We have developed main stages in the qua lime trie forecasting to model the expected quality of agricultural products and possible ways to achieve it. The proposed stages of qualimetric forecasting were tested when creating new curd products and their effectiveness has been proven.

Key words: competitiveness, quality; *quality management, qualimetry, forecasting, assessment, agricultural products, food products.*

Under modem conditions, Russian agrarian market with its fierce competition imposes an important task on domestic processing plants who need to produce competitive products -to meet the ever-increasing consumers' demands for quality [3, 17]. An effective way to achieve it is to use a synthesis of international and domestic experience in quality management and assessment [2, 4, 13]. The key principles of Total Quality Management (TQM), i.e. "focus on consumers" and "making decisions based on facts" [7, 16, 20] are implemented by qualimetric methods and qualimetric forecasting [12] in particular.

Qualimetric methods as well as the qualimetric forecasting were originally developed and widely used in the engineering industry [8,13]. In scientific literature, there are also data on the development and application of qualimetry in such areas as pedagogy, economics, architecture and construction. Despite the high efficiency of qualimetric methods, including qualimetric forecasting, their use in agribusiness sector to control quality of agricultural products and services is sporadic.

Quality forecasting based on the qualimetric principles is a relatively new scientific field still being in the process of formation. At the moment, qualimetric forecasting is understood as a complex of all prediction, or forecasting methods, which allow to anticipate significant changes in nature, structure and scope of customers' requirements to specific quality components of products or the quality of produce in general, and to ensure meeting requirements in future and high competitiveness on this basis [12].

Manufacturers and developers of new agricultural products face a number of challenges in the planning process, i.e. the necessity to analyze weak points, such as insufficient information about both external and internal consumer demands for certain product characteristics and the expected product quality [3, 11, 17].

To solve the outlined problems, some milestones were marked in qualimetric forecasting to model agricultural product quality at different stages of production, transportation, processing and marketing and to determine ways of achieving the expected quality. The main objective when designing the expected quality is to ensure the product quality at the stage of planning considering the consumers' demands and expectations.

The proposed main stages in qualimetric forecasting for agricultural products, food products in particular, are the following successive actions:

- developing special consumer evaluation profiles, or questionnaires, to determine and predict the expected customer demands for the product quality;
- sociological research by using questionnaires designed to study and predict marketed products;
- ranking and setting cogency coefficients to indicate consumer preferences;
- establishing a nomenclatural system of quantifiable quality parameters of goods;
- forming a product quality correlation matrix;
- assessing competitors' product quality in order to investigate on the customer satisfaction with their production;
- forming a consumer demand matrix based on QFD methodology;
- establishing qualitative standards tailor-made to develop a product meeting the forecasted consumer demands;
- forming a product quality and safety tree including consumer preferences and security indicators as well as authentication parameters;
- developing a complex product quality formula;
- suggesting ways to ensure the expected product quality;
- transforming expected product characteristics into specific manufacturing operations (technological process conditions, working out a formula, selecting raw components, packaging type, etc.) to provide a new consumer product with planned characteristics and form process quality and product component matrixes based on QFD methodology;
- processing a test batch of the product to update and refine technological parameters;
- determining a complex quality index to assess consumer satisfaction with the new product;
- determining the demand for products and their competitiveness to provide a benchmark for expected quality of the new products as compared to competitors' products;
- standardizing the results of qualimetric forecasting.

The proposed stages in qualimetric forecasting have been tested in an attempt to improve the quality of two types of curd products (i.e. curd cheeses and curd desserts).

Research Methods

The following methods and quality assessment tools were used to implement the proposed qualimetric prediction stages in developing new types of curd products:

- a "brainstorming" method [9] was implemented to develop special consumer demand profiles (questionnaires);
- case studies were conducted by means of a sociological survey [17] of 250 respondents and processed by statistical methods to assess expert consistency [7];
- cogency coefficients of consumer preferences were established by pair testing [19];
- correlation analysis [17], QFD matrix methodology [14], QFD chart methodology [12, 15], expert assessment and expert consistency [7] were implemented to form a consumer demand matrix;
- target values of quality parameters were conducted on the basis of QFD methodology [11];
- a product quality and safety tree with cogency coefficients was developed on the basis of the properties tree methodology [12] and the hierarchical principle of classification [10];

- qualitative assessment of the product was conducted on the basis of the complex assessment methodology [3, 6];

- transformation of expected consumer product characteristics into specific manufacturing operations was carried out by using Pareto charts [14] to identify the most important product quality factors; process quality and product component matrixes were constructed on the basis of QFD methodology [14]; formula components were selected and modes of production were developed on the basis of complete factorial experiment methodology [7] (critical shear stress was considered as the target function and measured by means of «STANHOPE-SETA» penetrometer [5], moisture-binding ability and plasticity were measured using Grau method modified in All-Russian Research Institute of Meat Industry [5]. The following factors were taken as controlled ones and considered: fat-free skim milk cheese fraction - in the range from 25 to 80%, pasteurization temperature - in the range from 67 to 95 °C, and the weight fraction structure-forming collagen-containing agents of three types with the variation range: SCANPRO T 95 - from 0.3 to 1.0%; SCANPRO BR 95 and Tipro 601 - from 0.5 to 2.0%.

- a comparative assessment of consumer satisfaction with new product quality included the complex assessment methodology [3, 6], expert assessment [12] and expert consistency [7].

All experiments were conducted in 3-5 replications, the data obtained were processed by means of mathematical statistics [7] methods.

Key results

A complex research was conducted to test the proposed stages of qualimetric forecasting with the development of some new curd products taken as an example. The main results of this research are the following:

1. Three types of target profiles for sociological research were elaborated to determine the consumer evaluation and predict the expected quality of curd products. *Type 1 profiles* identify the target consumers of these curd products, the list of consumer preference indicators and reveal the demands for the expected product quality expressed in "the consumer language"; *tope 2 profiles* are meant to set the cogency coefficient and rank consumer preference indicators; *type 3 profiles* are to perform the consumer quality assessment of marketed curd products.

2. As a result of the analysis of curd products market and sociological survey of 250 respondents, the list of consumer preference indicators was compiled, the cogency coefficients of curd products quality parameters were ranked and defined (Figure 1). The demands for the expected quality of curd products expressed in "the consumer language" were defined. The expected products quality parameters possessing the high values of cogency coefficients (%) were identified. They are: taste (15.3%), healthiness (13.4%), lack of wheying (12.7%), obvious presence of filler pieces (10.3%), homogeneous consistency (9.5%), absence of preservatives, flavouring and colouring agents (9.3%) and long shelf life (9.1%).

3. Two consumer demand matrixes for curd desserts and curd cheeses (Figure 2) were developed on the basis of the revealed correlation between the quality parameters of curd products, the quality assessment of competitors' products and the degree of consumer satisfaction with the products. The target values of quality parameters for curd desserts and curd cheeses were also established.

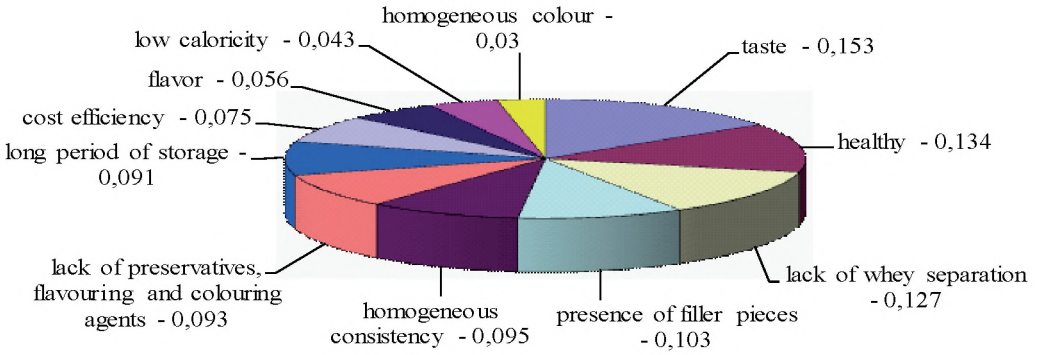


Fig. 1. Cogency coefficients diagram of consumer preference indicators for the curd products

4. The quality and safety tree for the studied curd products with cogency coefficients of all three levels was formed and complex quality formulas for curd products were proposed:

consumer preference-based assessment:

$$K = 15.3k_1 + 5.6k_2 + 9.5k_3 + 10.3k_6 + 9.3k_7 + 13.4k_8 + 9.1k_9 + 4.3k_{10} + 7.5k_{11}$$

where K - a complex parameter of curd products quality, considering consumer preference indicators, %; $k_{1...}$ k_{11} - relative parameters of curd product quality: 1 - taste, 2 - smell, 3 - homogeneous consistence, 4 - colour, 5 - lack of wheying, 6 - obvious presence of filler pieces, 7 - shelf life, 8 - healthiness, 9 - absence of preservatives, flavouring and colouring agents, 10 - energy value, 11 - reasonable price; b) considering the assessment of quantifiable parameters of curd products quality:

- for curd desserts:

$$Q = 7.1q_1 + 5.3\ q_2 + 11.9q_3 + 6.3q_4 + 7.9q_5 + 4.0q_6 + 3.2q_7 + 2.0q_8 + 4.3q_9 + \\ + 8.5q_{10} + 4.5q_{11} + 7.1q_{12} + 6.7q_{13} + 6.7q_{14} + 8.3q_{15} + 4.2q_{16} + 8.4q_{17}$$

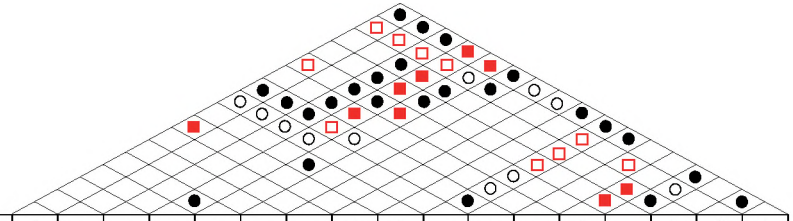
– for curd cheeses:

$$Q = 7.1q_1 + 2.7\ q_2 + 11.5q_3 + 6.3q_4 + 7.7q_5 + 3.9q_6 + 3.1q_7 + 2.0q_8 + 4.1q_9 + \\ + 7.0q_{10} + 4.4q_{11} + 6.8q_{12} + 6.6q_{13} + 6.6q_{14} + 8.0q_{15} + 4.1q_{16} + 8.2q_{17}$$

where Q - a complex parameter of curd products quality displaying the actual values of target quality parameters and their relative weight, %: $q_{1...}$, q_{17} - relative parameters of curd products quality: weight fractions: 1 - fat, 2 - sugar (curd desserts) or salt (curd cheeses), 3 - protein, 4 - water; the quantity of: 5 - structure-forming agents, 6 - preservatives, 7 - flavouring agents, 8 - colouring agents, 9 - functional additives, 10 - filler; 11 - energy value; 12 - acidity; 13 - plasticity; 14 - critical shear stress; 15 - moisture-binding ability; 16 - shelf life and 17 - price.

The relative parameters of consumer preferences quality (k_1 and q,) of the 1st characteristic are determined as a target value of the 1st quality parameter to the product value parameter ratio. At that, the ratio of numerical values of quality parameters is compiled in such a way that with the increasing quality it tends to 1 and with the decreasing quality it tends to 0.

5. The proposals to ensure the expected quality of new curd products were developed. These proposals include the reasons for choosing raw components influencing the target



direction of improvement				↓	-	-	-	-	-	-	↓	↑	-	↓	-	↓		↑	↑	↓						
Row number	Consumer preferences indicators	Quantifiable indicators of quality	Importance for consumer	Fat content	Sugar content	Protein content	Water content	Amount of structuring agent	Preservatives content	Flavourings content	Colourings content	Functional additive content	Filler amount	Energy value	Acidity (titrable)	Softness	Critical shear stress	Water-binding capacity	Product shelf life	Product cost	Product A	Product B	Product C	Product D	Product E	Planned quality
1	Sensorial indicators	Taste	5,0			●										●	●				4,3	3,7	4,6	4,5	4,3	5,0
2		Odour	1,8		Δ	●										Δ	Δ	Δ			4,2	3,7	3,8	4,4	4,2	4,4
3		Texture	3,1		Δ																4,3	3,7	4,2	4,5	4,1	4,5
4		Colour	1,0																		3,9	4,2	4,1	4,2	4,1	4,2
5		Absence of whey	4,2		Δ																3,5	4,5	4,5	4,5	4,1	4,5
6	Composition indicators	Filler pieces presence	3,4																		4,3	3,6	4,1	4,2	4,1	4,3
7		No preservatives, flavourings and colourants	3,0																		4,1	3,3	4,3	4,3	4,1	4,3
8	Economical indicators	Reasonable price	2,5																		3,8	3,9	4,5	3,1	3,9	4,5
9	Ergonomical indicators	Healthiness	4,4																		4,1	3,8	4,3	4,9	4,3	4,9
10		Low calories	1,4				Δ	●													3,5	3,7	4,4	4,5	4,3	4,5
11	Storage ability indicators	Long shelf life	3,0																		4,9	3,8	4,7	4,7	4,5	4,9
12	Quality indicators importance			134,7	100,6	225,6	119,8	149,4	76,4	60,7	38,5	80,3	161,2	84,9	134,7	125,7	125,7	157,2	79,6	159,3						
13	Relative weight of quality indicators, %			7,1	5,3	11,9	6,3	7,9	4,0	3,2	2,0	4,3	8,5	4,5	7,1	6,7	6,7	8,3	4,2	8,4						
14	Technical competition assessment	Product A		4,4	3,5	3,9	3,9	3,8	4,6	4,1	4,9	3,7	4,2	3,8	4,1	4,0	4,0	3,5	4,8	3,3						
15		Product B		3,9	4,0	4,7	4,2	3,3	4,7	3,3	3,8	3,9	3,6	3,9	3,5	3,5	3,5	4,5	3,8	3,7						
16		Product C		4,3	3,9	3,9	4,0	3,8	4,5	4,0	4,7	4,0	4,1	4,4	4,5	3,9	3,9	4,5	4,7	4,3						
17		Product D		4,5	4,1	4,3	4,3	4,1	4,9	4,1	4,3	4,7	4,2	4,5	4,4	4,4	4,4	4,5	4,7	3,3						
18		Product E		4,3	3,9	4,1	4,1	4,2	4,7	4,4	4,3	4,1	4,1	4,3	4,5	4,1	4,1	4,1	4,5	3,6						
19	Quality planning	Planned quality		5,0	4,1	4,7	4,3	4,2	4,9	5,0	4,7	4,7	4,2	4,5	4,5	4,4	4,4	4,5	4,8	4,3						
20	Controlled quality indicators	units		%	%	%	%	e/l	unit	unit	unit	unit	ball	ccal	°T	cm²/g	Pa	%	Day	RUR.						
21		Target quality indicators		3,7	-	-	-	-	no	no	no	1	-	115	-	17,2	105	32,4	30	16,80						

Legend

○ Weak positive correlation

□ Weak negative correlation

● Strong positive correlation

■ Strong negative correlation

Connection binding:

● Strong (weight 9)

○ Medium (weight 3)

Δ Weak (weight 1)

Improvement directions binding:

↑ Indicator value increase

↓ Indicator value decrease

\- Nominal value of indicator

Fig. 2. Matrix of Consumer requirements for quark desserts

Suggested formula options for the curd desserts and curd cheeses

Component	Component weight fraction in the formula					
	Curd dessert			Curd cheese		
	1	2	3	4	5	6
Fat-free curd	66.5	66.5	66.4	39.4	38.8	39.2
Cream with 10% fat weight fraction	33.0	33.0	33.0	-	-	-
Cream with 20% fat weight fraction	-	-	-	60.0	60.0	60.0
SCANPRO T95	0.5	-	-	0.6	-	-
SCANPRO BR 95	-	0.5	-	-	1.2	-
Tipro 601	-	-	0.6	-	-	0.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

values of curd products quality parameters. The main ways to improve the quality of curd products are as follows: to obtain homogeneous consistency using structure-forming agents; to decrease fat weight fraction and energy value; to use natural ingredients, safe for consumer health; to reduce the production cost; to introduce healthy components; to extend shelf life without adding preservatives.

6. On the basis of a complete factorial experiment the production technology and formulation for the curd desserts and curd cheeses (see Table) was developed. The target values were set: fat weight fraction (3.7% and 12.5% respectively), critical shear stress (105 and 240 PA respectively) and heat treatment temperature (80-85°C with 1-minute exposure) ensuring the desired shelf life (30 days). The technology was tested in the conditions of a commercial production process.

7. The samples of curd desserts and curd cheeses manufactured in the above mentioned production process were used for measuring the actual values of the target quality parameters of curd products and for the assessment of consumer preference parameters. The results are shown in Figure 3.

The values of the complex quality parameter K characterizing consumer preferences for new curd desserts and curd cheeses accounted for 95.5% and 98.1% respectively; the values of the complex quality parameter Q characterizing the quantifiable parameters assessment accounted for 98.5% and 98.2% respectively. It has been proven that the developed products meet consumer expectatons which ensures high demand for and competitive advantages of these products.

8. The relevant technical documentation was approved (specification and instructions 9222-050-02068640 "Pasteurized curd cream"', specification and instructions 9222-051- 02068640 "Pasteurized curd paste").

Two patents for inventions [1, 18] display how an innovative product can benefit from a solid scientific substantiation.

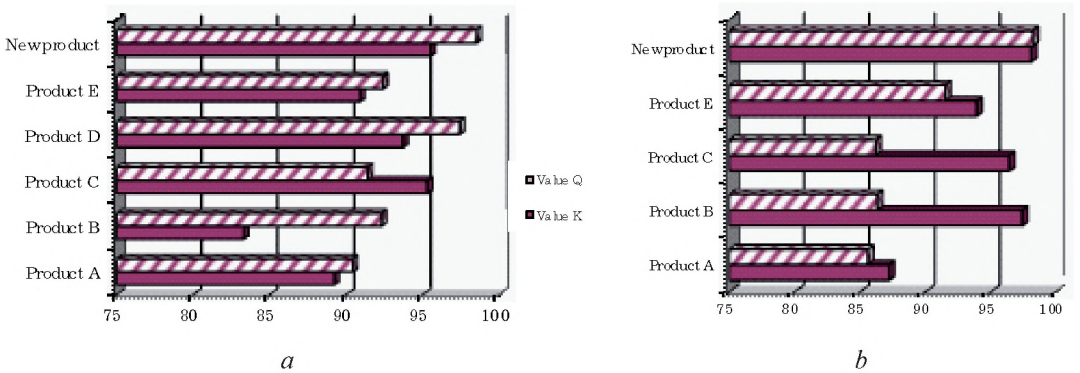


Fig. 3. The comparative assessment of quality parameters of the developed curd products: a - curd desserts; b - curd cheeses

Conclusion

The data obtained confirm that the proposed stages of qualimetric forecasting allow to develop products that meet consumer demands and minimize efforts to improve the quality of marketed commodities.

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Translated into English by: lect. I.V. Avdeeva, lect. A.V. Potapova,
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ПРИМЕНЕНИЕ КВАЛИМЕТРИЧЕСКОГО ПРОГНОЗИРОВАНИЯ В АПК

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Аннотация: одним из эффективных путей повышения конкурентоспособности продукции АПК является применение квалиметрического прогнозирования. При этом отсутствует четкая методология проведения квалиметрического прогнозирования вАПК-секторе. Авторами разработаны основные этапы квалиметрического прогнозирования качества продукции, позволяющие прогнозировать ожидаемое качество сельскохозяйственной продукции и сформировать способы его достижения. Предложенные этапы квалиметрического прогнозирования апробированы при создании ряда творожных продуктов и доказали свою эффективность.

Ключевые слова: конкурентоспособность, качество, управление качеством, квалиметрия, прогнозирование, оценка, сельскохозяйственная продукция, пищевая продукция.

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